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**ENVIRONMENTAL SOUND SURVEY AND
NOISE IMPACT ASSESSMENT**

**GRANITE RELIABLE POWER, LLC
PROPOSED WINDPARK**

**COOS COUNTY
NEW HAMPSHIRE**

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1.0 INTRODUCTION

Hessler Associates, Inc. has been retained by Noble Environmental Power to evaluate potential environmental noise impacts from a proposed wind energy conversion project being developed in Coos County, New Hampshire. Plans for the Granite Reliable Power Project (The Project) currently call for the installation of 36 Vestas V90 wind turbines along an irregular ridgeline within two large tracts of private land south of Dixville Notch. Each turbine, with a nominal maximum power output of 3 MW, will be mounted on a tubular tower approximately 80 m high and have a 90 m diameter, three-bladed rotor.

The study essentially consists of two phases: a background sound level survey and a computer modeling analysis of future turbine sound levels. The field survey of existing sound levels at the site was carried out to determine how much natural masking noise there might be - as a function of wind speed - at the nearest potentially sensitive receptors to the Project. The relevance of this is that high levels of background noise due to wind-induced natural sounds, such as tree rustle, would tend to reduce the audibility of the wind farm, while low levels of natural noise would permit operational noise from the turbines to be more readily perceptible. The audibility of and potential impact from any new noise source is largely a function of how much, if at all, it exceeds the pre-existing background level at a potentially sensitive noise receptor location.

In the second phase of the assessment an analytical noise model of the Project was developed to predict the sound level contours associated with the Project over the site area and thereby determine the potential for perceptibility relative to the background sound level.

2.0 BACKGROUND SOUND LEVEL SURVEY

2.1 OBJECTIVE AND MEASUREMENT QUANTITIES

The purpose of the survey was to determine what minimum environmental sound levels are consistently present and available at the nearest potentially sensitive receptors to mask or obscure potential noise from the Project. A number of statistical sound levels were measured in consecutive 10 minute intervals over the entire survey. Of these, the average (Leq) and residual (L90) levels are the most meaningful.

The average, or equivalent energy sound level (Leq), is literally the average sound level over each measurement interval. This is the “typical” sound level most likely to be observed at any given moment.

The L90 statistical sound level, on the other hand, is commonly used to conservatively quantify background sound levels. The L90 is the sound level exceeded during 90% of the measurement interval and has the quality of filtering out sporadic, short-duration noise events thereby capturing the quiet lulls between such events. It is this consistently present “background” level that forms a conservative or “worst-case” basis for evaluating the audibility of a new source.

An additional factor that is important in establishing the minimum background sound level available to mask potential wind turbine noise is the natural sound generated by the wind itself. Wind turbines only operate and produce noise when the wind exceeds a minimum cut-in speed of about 3 m/s (measured at a reference elevation of 10 m). Turbine sound levels increase with wind speed up to about 8 to 10 m/s when the sound produced generally reaches a maximum and no longer increases because the rotor has reached a predetermined maximum rotational speed. Consequently, at moderate to high speeds when turbine noise is most significant the level of natural masking noise is normally also relatively high due to tree or grass rustle thus reducing the

perceptibility of the turbines. In order to quantify this effect wind speed was measured over the entire sound level survey period by an existing met tower on the site for later correlation to the sound data.

2.2 SITE DESCRIPTION AND MEASUREMENT POSITIONS

The proposed Granite Reliable Power Project is located within a nearly 84,000 acre tract of private land, made up of several adjoining parcels, south of Dixville Notch in Coos County, NH. The turbines are generally proposed along the crest of a wooded ridgeline that is quite remote from any potentially sensitive receptors. The nearest off-site residence is nearly 3 miles away from the closest turbine and in most directions there are no homes for many miles. On the site property there are a small number of seasonal cabins and cottages located a considerable distance from the nearest turbines on parcels that are leased from the property owner.

In order to measure existing background sound levels that are representative of those experienced at the nearest homes and potentially sensitive receptors, sound level monitors were set up at 8 positions at or close to the nearest potential receptors in all directions. In addition to homes potentially sensitive receptors in the area include Dixville Notch State Park and the Balsams Resort both located to the north of the Project area.

Graphic A shows the site area, the proposed turbine locations and the sound level monitoring stations, which are also described below.

Position 1 – Bungy Road – Nearest Homes West of Project

Monitor 1 was situated on a utility pole along Bungy Road where it most closely approaches the Project. There are a number of homes along this road and in this general vicinity. The nearest residence in this area is approximately 3.5 miles west of the Project. The monitor position was at the edge of a field near some brush and small trees and close to the nearest homes to the Project area.



Figure 2.2.1 *Monitor 1 – Looking Southeast Generally Towards the Project Area*



Position 2 – Southern Property Line

Monitor 2 was located behind an unused building close to the southern property line of the Project land parcels. This location was chosen to represent several homes just outside the property line along Paris Road. The monitor was attached to a large evergreen tree behind the building.



Figure 2.2.2 *Monitor 2 – Looking North Towards the Project Area*

Position 3 – Phillips Pond – Nearest Seasonal Cabin West of Project

Monitor 3 was located in a wooded area near the shore of Phillips Pond, which is about 2 miles west of the turbines and still within the Project land. There is one seasonal cabin on this pond.



Figure 2.2.3 *Phillips Pond Looking West – Monitor in Wooded Area on Left*

Position 4 – Millsfield Pond

Monitor 4 was located in the woods near the shore of Millsfield Pond, which is a little under 2 miles from the nearest proposed turbine locations. There are a number of seasonal cottages mostly located along the south shore of this lake on parcels of land leased from one of the principal Project landowners. This monitoring position was chosen to capture the typical background sound level at these cabins.



Figure 2.2.4 *Millsfield Pond Looking NW towards the Project –
Monitor 4 Located in Woods behind this Vantage Point*

Position 5 – Nearest Residence East of Project

Monitor 3 was located near the Peace of Heaven Bed and Breakfast on Route 26. This is the nearest permanent residence off of the site property to the east of the Project (roughly 2.7 miles from the nearest turbine). The meter was located at the edge of a wooded area roughly 70 ft. west of Route 26 and about 300 ft. south of the entrance to the bed and breakfast.



Figure 2.2.5 *Entrance to B&B Viewed from Monitor 5*

Position 6 – Dixville Notch State Park

Monitor 6 was located on Project land just outside the southern boundary of Dixville Notch State Park. The meter was set back approximately 100 yards west of Route 26 to the side of a trail originating at a parking area immediately south of the park. The entire area is wooded and the monitor was attached to a tree.



Figure 2.2.6 *Monitor 6 – Looking North*

Position 7 – The Balsams Resort

Monitor 7 was placed behind the resort above the remote parking lots in a wooded area near the spring house. This out-of-the-way location was chosen so that the natural sound level in the immediate vicinity of the resort could be recorded without too much contamination from activity in the resort itself.



Figure 2.2.7 *Monitor 7 – Looking Southeast towards spring house – resort beyond and below.*



Position 8 – The Balsams Ski Area

Monitor 8 was located along a typical ski run a short distance up the mountain from the base area.



Figure 2.2.8 *Monitor 8 – Along a Typical Ski Run
(snow making machines in background)*

2.3 INSTRUMENTATION AND SURVEY DURATION

Rion Model NL-06, NL-22 and NL-32, ANSI Type 2, integrating sound level meters were used for the survey. Each instrument was enclosed in a weatherproof case fitted with a 12" microphone boom. The microphones were protected from self-induced wind noise by oversized, 7 inch diameter windscreens (ACO Type WS7-80T). All the microphones were located at a height of about 1 m above local ground level and positioned away from the instrument box and away from any nearby reflective surfaces.

All the instruments were field calibrated with a Brüel and Kjær Type 4230 calibrator at the beginning of the survey and again at the end of the survey. The observed calibration drift was positive in all cases and ranged from +0.1 dB to +0.3 dB with the majority of the instruments in the lower end of this range.

Each of these instruments is designed for service as a long-term environmental sound level data logger measuring the A-weighted sound level. The meters were all set to continuously record a number of statistical parameters in 10 minute increments, such as the average (Leq), minimum, maximum, and residual (L90) sound levels. The survey period lasted 14 days beginning around midday on 10/9/07 and ending on the morning of 10/23/07.

As can be seen in some of the photographs in Section 2.2 taken at the beginning of the survey most of the trees still had leaves on them. At the end of the survey the foliage was generally much thinner but only a few trees were bare.



2.4 SURVEY WEATHER CONDITIONS

The weather conditions during the survey were mostly overcast with periods of intermittent light rain and morning fog. Two periods of heavier rain occurred during the early morning hours of Oct. 12 and during the overnight period on Oct. 19 and 20.

The general weather parameters of temperature, barometric pressure and wind for the survey period, as observed in at Colebrook, NH, about 11 miles west of the Project area, are illustrated in the graph below.

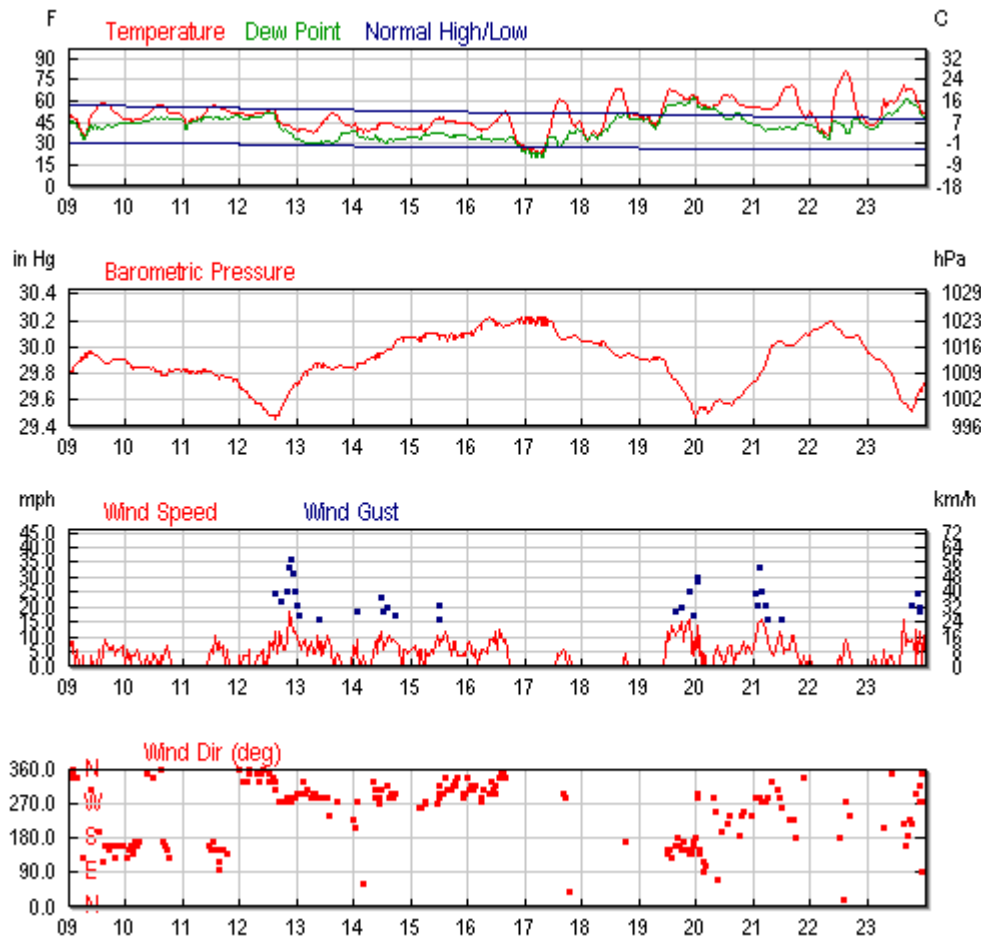


Figure 2.4.1 General Weather Data for the Survey Period as Observed in Colebrook, NH

The wind speed at the site itself was measured at a met tower (Tower 40) located near the center of the Project along the ridge line where the turbines are planned. Figure 2.4.2 below shows the wind speed measured in 10 minute increments at the anemometer height of 49 m and the wind speed normalized to a standard elevation of 10 m in accordance with IEC Standard 61400-11 [Ref. 1]. This 10 m height, explained in more detail in Section 2.6 below, is relevant because wind turbine sound levels are expressed as a function of wind speed at this elevation.

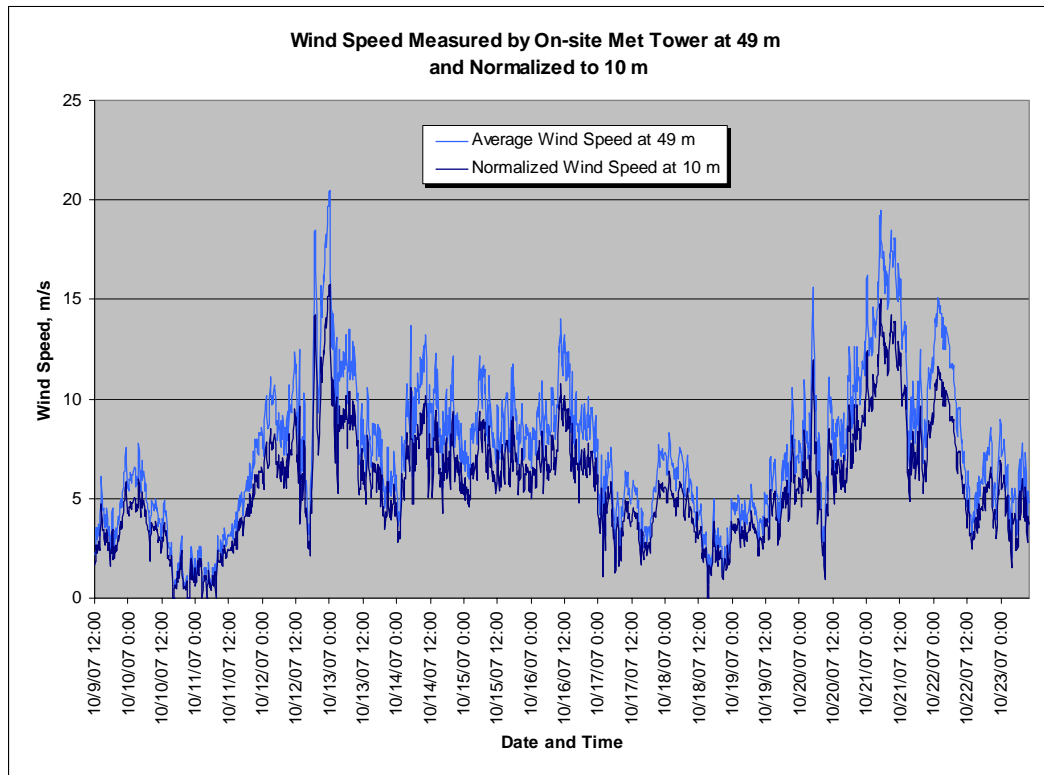


Figure 2.4.2 *Wind Speed vs. Time Measured by On-Site Met Tower During the Survey Period*

This plot shows that winds were moderate (between about 5 and 10 m/s) much of the time and that several periods of high winds were captured during the survey.

2.5 OVERALL SURVEY RESULTS

As discussed above in Section 2.1 the L90, or residual, sound level is a conservative measure of background sound levels in the sense that it filters out short-duration, sporadic noise events that cannot be relied upon to provide consistent and continual masking noise to obscure potential turbine noise. This level represents the quiet, momentary lulls between all relatively short duration events, such as cars passing by or tractor activity in a neighboring field. As such, it is the near “worst-case” background level with regard to evaluating potential impacts from a new source.

The L90 sound levels over consecutive 10 minute periods for all 8 positions are plotted below in Figure 2.5.1.

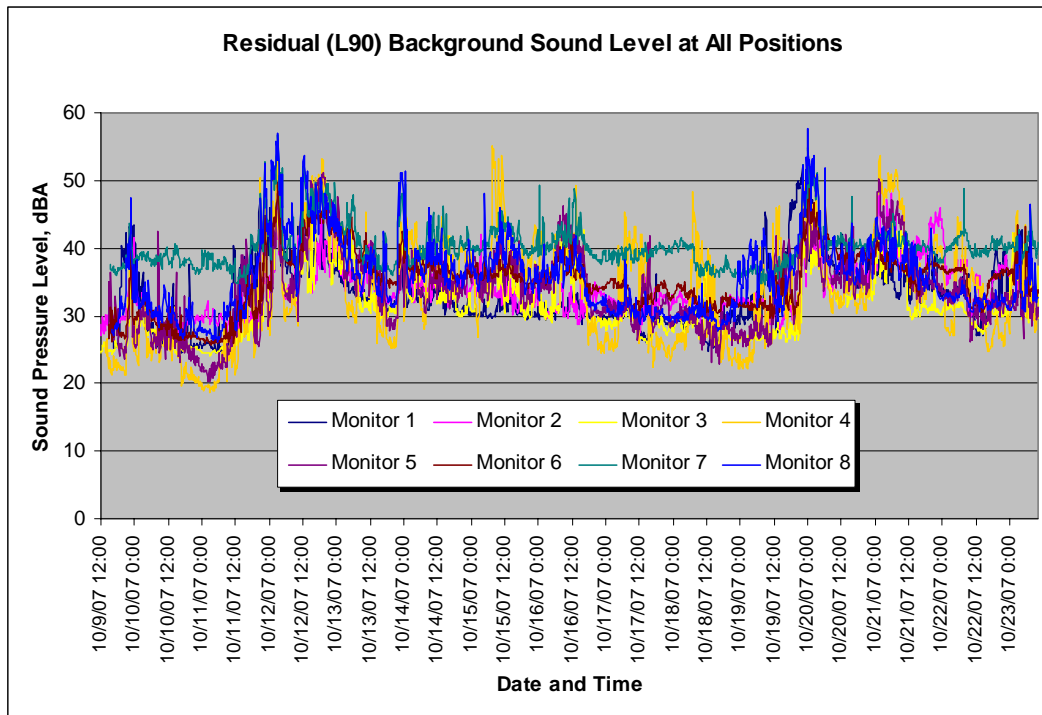


Figure 2.5.1 10 minute L90 Sound Levels at All Monitoring Positions

This plot shows that the L90 sound levels at these very widely distributed locations generally follow the same trends - except at Positions 4 and 7. Without these two positions the consistency in sound levels at the remaining 6 is more clearly visible as shown in Figure 2.5.2.

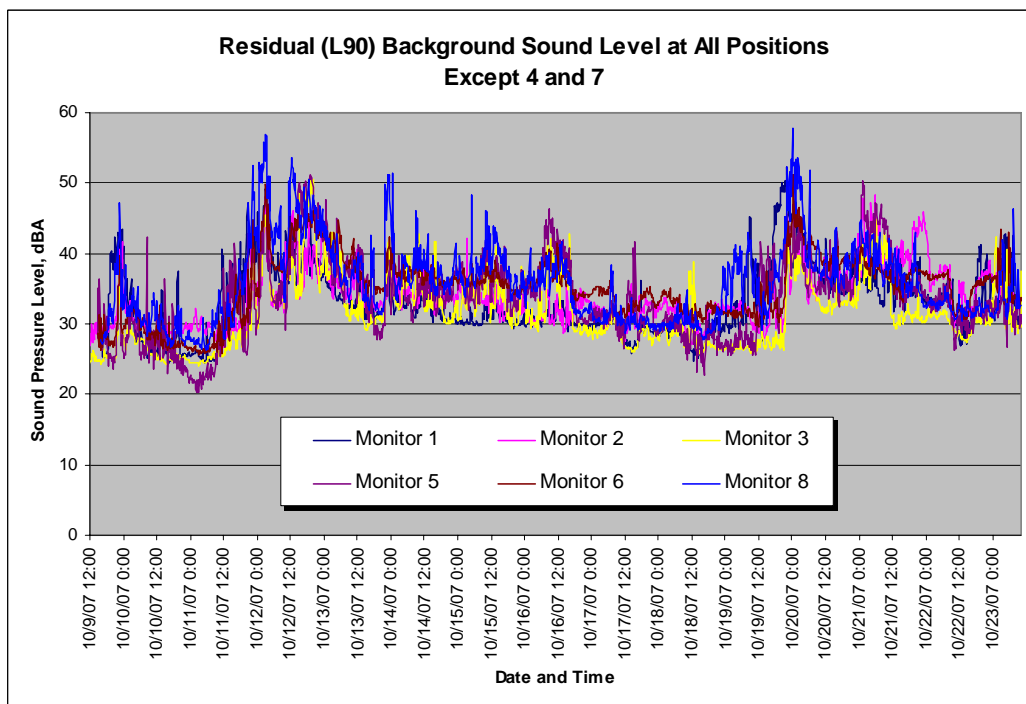


Figure 2.5.2 10 minute L90 Sound Levels at All Monitoring Positions – Except 4 and 7

The consistency in level and behavior as a function of time between these 6 monitoring stations is remarkable given the fact that they were spread out over an area of roughly 85 square miles in a variety of settings. Monitors 2 and 8, for example, at the southern and northern ends of the Project area were about 14 miles apart. Because of this uniformity it can be concluded that the average sound level of these 6 positions would reasonably represent the sound level anywhere in the vicinity of the site – except perhaps around Positions 4 and 7 – and can be used as a design level. The average sound level for the 6 locations plotted in Figure 2.5.2 is shown below.

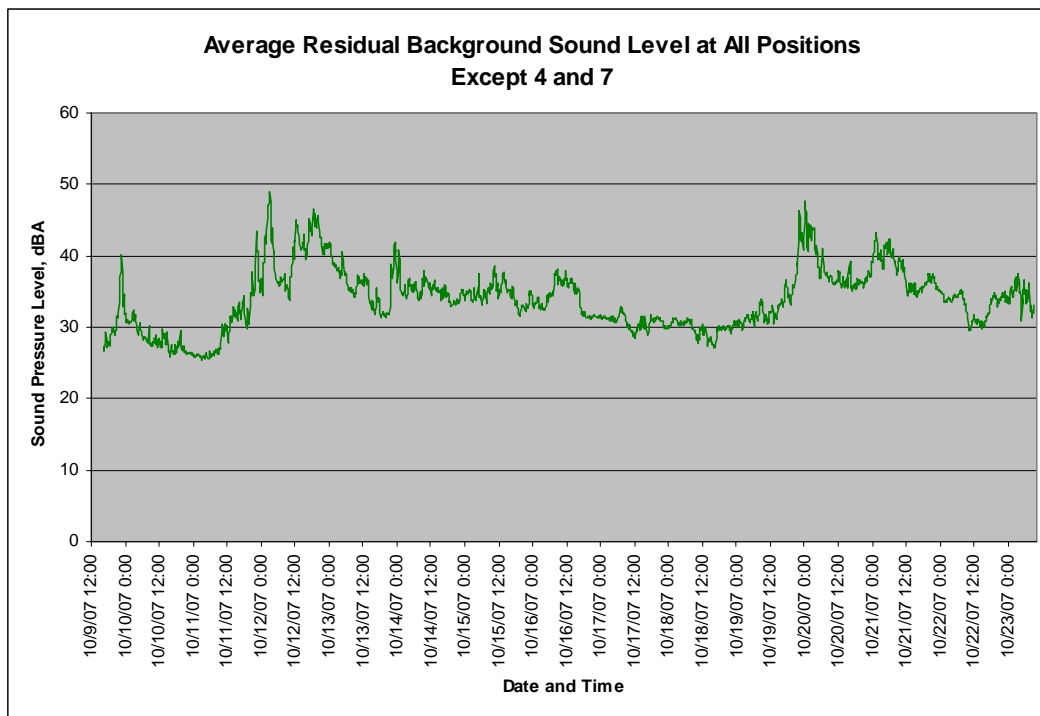


Figure 2.5.3 Average *L*₉₀ Sound Levels at All Monitoring Positions Except 4 and 7 – Design Level

Figure 2.5.4 below compares the average, or design, sound level to the level measured at Position 7 (The Balsams Resort). This plot indicates that the design level is significantly lower than the actual level at Position 7 all of the time - so the design level can be considered a very conservative measure of the natural background level around the Balsams Resort. The reason the measured levels at Position 7 are consistently higher than elsewhere is that noise from the on-site power generation plant at the hotel permeates the area. At the monitoring position, which was remote from the hotel and the power plant, this noise essentially maintained a minimum noise floor of about 37 to 40 dBA.

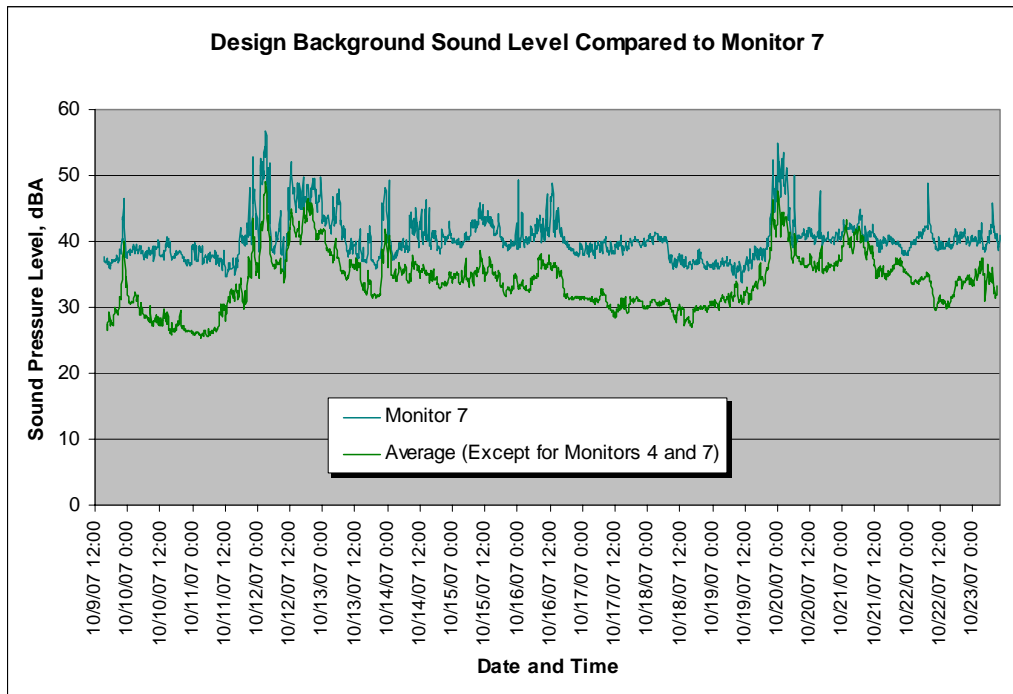


Figure 2.5.4 Design Level Compared to Position 7

The design level is compared to the sound level measured at the other anomalous position (Position 4) in Figure 2.5.5.

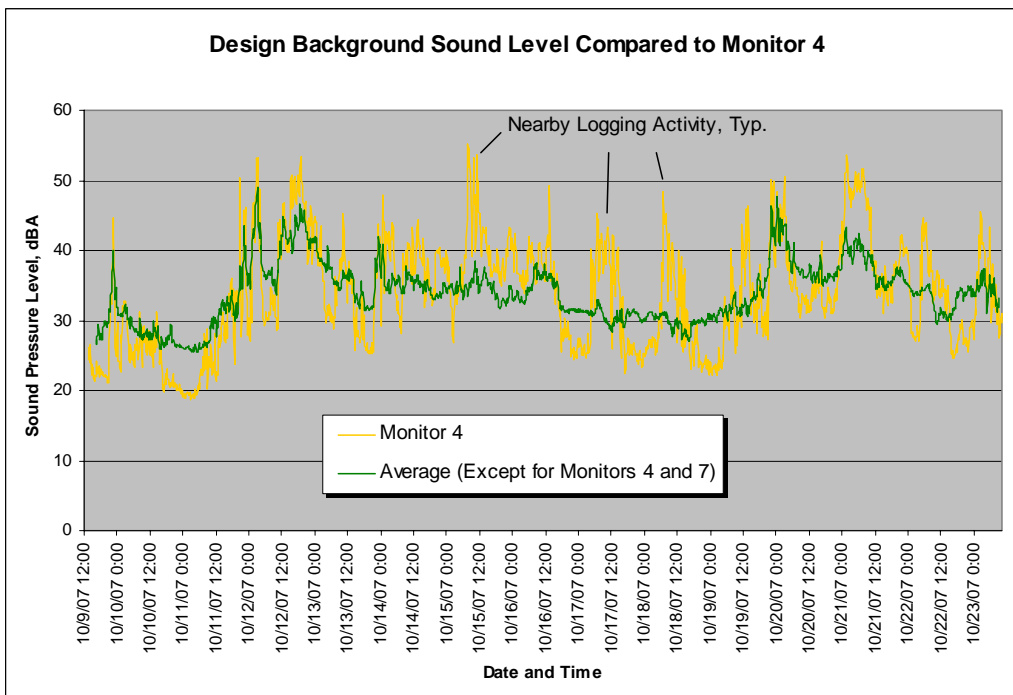


Figure 2.5.5 Design Level Compared to Position 4

In this case, the sound levels at Position 4 often exceed the design value but also go below it with some regularity. The high noise periods are believed to be associated with nearby logging activities, which were clearly audible on the day the instruments were retrieved from the site. The occasional low levels are apparently quiet periods occurring during calm winds – times when wind turbine noise is non-existent or minimal. Consequently, the design level is considered a satisfactory representation of the background level at Position 4 under conditions relevant to turbine operation; i.e. when the winds are moderate or higher.

Figure 2.5.6 compares the average background sound level to the wind speed measured by the on-site met tower.

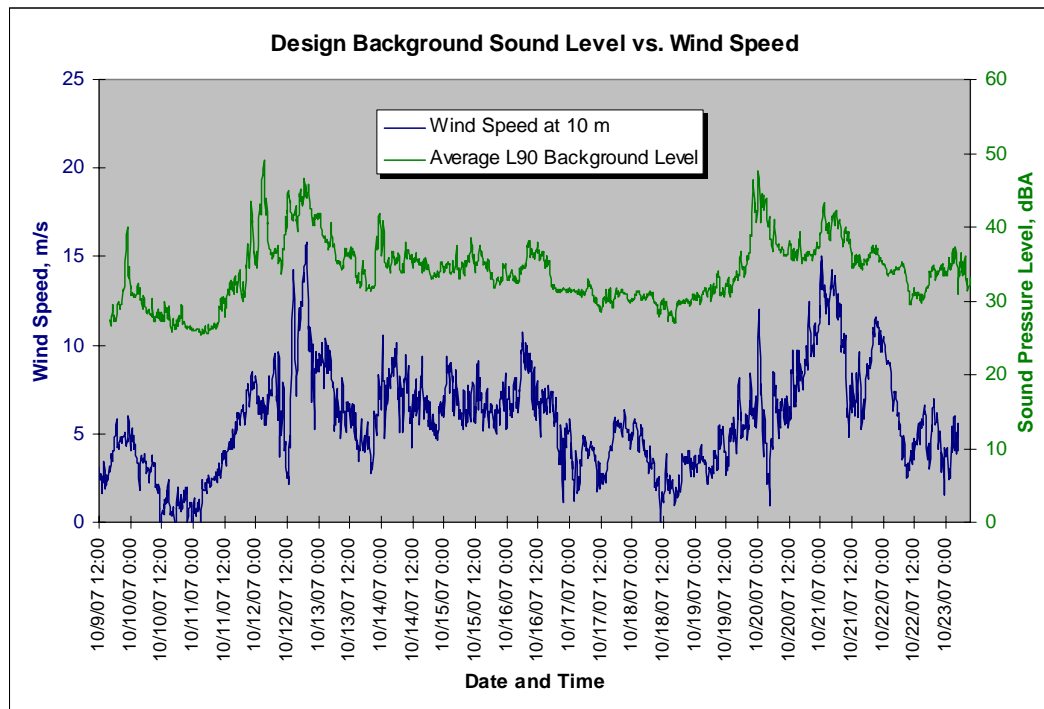


Figure 2.5.6 Design Sound Level Compared to Wind Speed

This plot shows that the near-minimum (L90) background sound levels over the site area are closely related to wind speed and largely driven by wind-induced natural sounds. The regression analysis in Figure 2.5.7 using the data from Figure 2.5.6 relates sound levels directly to wind speed.

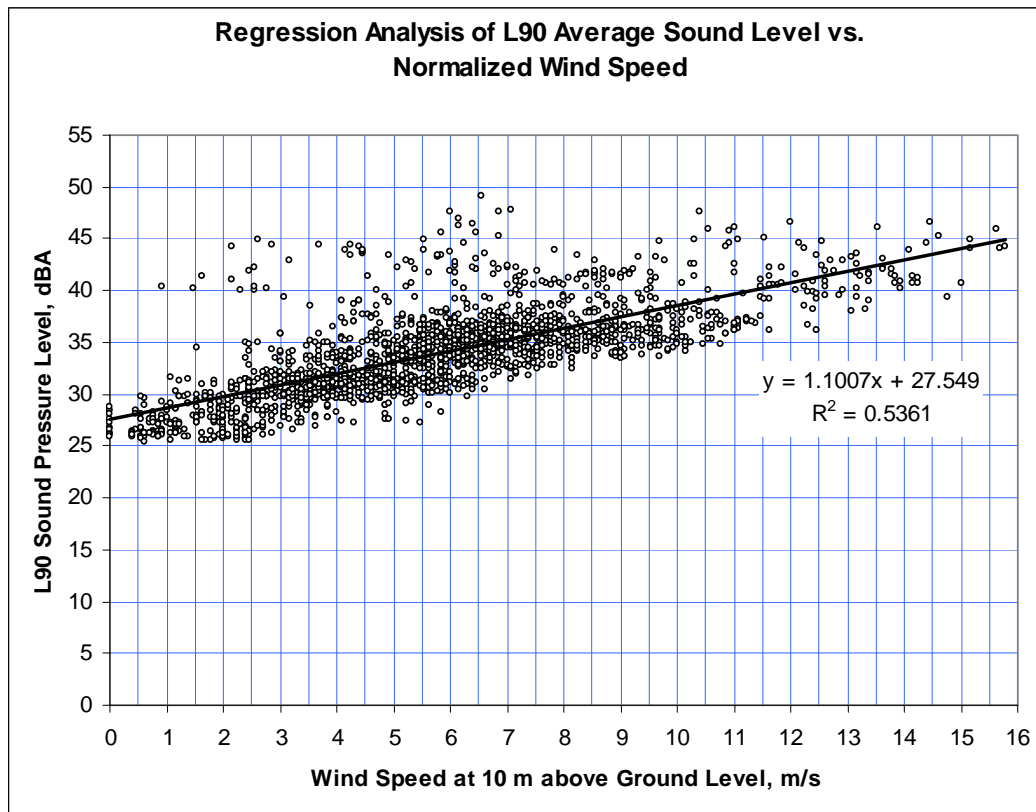


Figure 2.5.7 Correlation Between the L90 Background Level and Wind Speed

This plot shows that during calm conditions (when the Project is not operating) a very quiet minimum sound level of less than 30 dBA is likely to be observed in the virtual absence of any sporadic noise event. As the wind speed increases, however, the near-minimum (L90) level gradually increases as well.

The following table summarizes the background levels that characterize the site environment over the range of wind speeds relevant to turbine operation.

Table 2.5.1 Measured L90 Background Sound Level as a Function of Wind Speed

Integer Wind Speed at Standardized Elev. of 10 m, m/s	4	5	6	7	8	9	10
Worst-Case (L90) Sound Level, dBA	32	33	34	35	36	37	38

2.6 WIND SPEED AS A FUNCTION OF ELEVATION ABOVE GROUND LEVEL

Below about 100 m, wind speed varies with elevation above the ground due to friction with the surface and obstacles such as trees. Because this roughness varies from place to place measurements of wind turbine sound power levels carried out in accordance with IEC Standard 61400-11 [Ref. 1] are normalized to and reported in terms of the wind speed at a reference height of 10 m. This enables the nominal noise level of different makes and models of wind turbines to be compared on a uniform basis.

The conversion of wind speed at one elevation to the related speed at another elevation is calculated from a formula in the IEC standard (Equation (7), Section 8), which describes a logarithmic profile.

As an example the wind profile resulting from Eqn.(7) is shown graphically below in Figure 2.6.1 for the case where the wind is normalized to a speed of 8 m/s at 10 m. The shape of the profile curve varies with wind speed becoming flatter at low speeds and more curved at higher speeds.

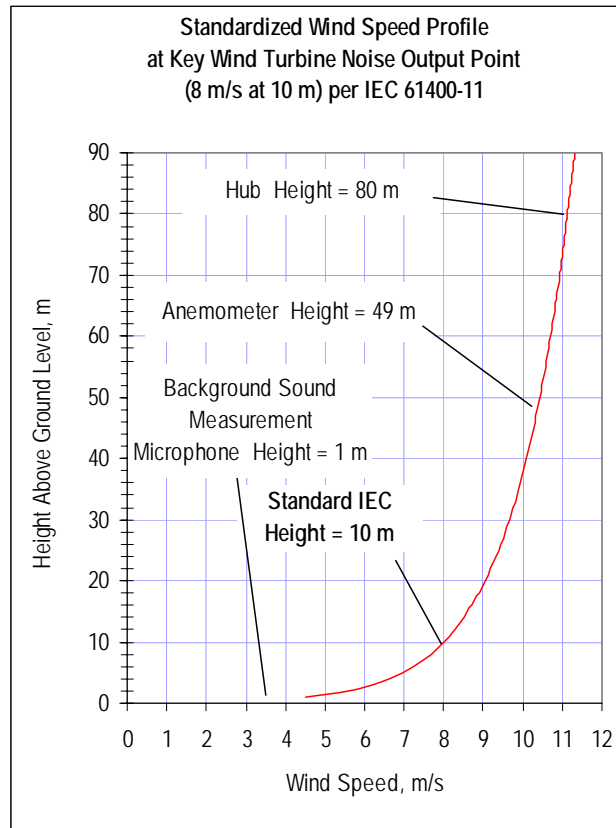


Figure 2.6.1 Wind Speed Profile above the Surface

3.0 PROJECT NOISE MODELING AND IMPACT ASSESSMENT

3.1 ASSESSMENT CRITERION

There are no national, state or local laws that would specifically limit Project noise. In the absence of any specific or absolute noise level limits potential noise impacts from the Project will be evaluated in terms of its likely audibility or perceptibility relative to the background sound level.

In general, a new broadband noise source without any distinctive character to it, such as tonality or impulsiveness, must have a sound level that is about 5 dBA higher than the background before it begins to be perceptible to most people. For wind turbines, however, the threshold of perception



is somewhat lower because the sound has a mildly periodic quality associated with blade “swish” that makes it more readily perceptible than a steady, bland sound of the same magnitude. The sound level rises and falls slightly at about 1 second intervals since only the downcoming blade briefly generates aerodynamic noise followed by a very short pause until the next blade comes around. This phenomenon, referred to as amplitude modulation, makes wind turbines more readily perceptible than other sounds of comparable magnitude and is often the root cause of complaints about wind turbine noise. Because of this characteristic wind turbine noise is sometimes perceptible when its overall A-weighted sound level is equal to the background level – instead of having to be 5 dBA above the background as is the case with many other sound sources.

Consequently, the threshold for potential adverse impact for this Project will be taken as the point where the Project sound level equals the L90 background level under comparable wind conditions. This criterion is conservative in the sense that the L90 is not a continuous or permanent sound level but rather only occurs, by definition, for brief periods during lulls in the natural background sound level. Comparing maximum turbine sound levels to this near-minimum background level essentially represents a worst-case approach.

3.2 TURBINE SOUND LEVELS

The starting point for any wind turbine noise modeling study is the sound level, or more specifically, the sound power level of the turbine model that will be used in the Project.

The sound power level of the Vestas V90-3.0 MW wind turbine, the model likely to be used for this Project, as a function of wind speed is known from field tests carried out by independent acoustical engineers for Vestas in accordance with IEC 61400-11 [Ref. 1]. The values are reported in a document entitled “General Specification V90-3.0 MW 60 Hz Variable Speed Turbine” [Ref. 2]. For an 80 m hub height the following sound power levels are published as a function of wind speed at the standardized measurement height of 10 m.

Table 3.2.1 Vestas V90-3.0 MW Sound Power Levels vs. Wind Speed

Wind Speed at 10 m Height, m/s	Sound Power Level, dBA re 1 pW
4	97.1
5	102.0
6	106.0
7	108.2
8	109.4
9	109.4
10	106.7

It is important to note in this context that a sound *power* level is not the same thing as a sound *pressure* level, which is the familiar quantity measured by instruments and perceived by the ear. A power level is a specialized, calculated measure, expressed in terms of Watts, that is primarily used for acoustical modeling and in design analyses. It is a function of both the sound pressure level produced by a source at a particular distance and the effective radiating area or physical size of the source. The basic mathematical relationship between power and pressure is as follows:

$$L_w = L_p + 10 \log (A), \text{ dB re 1 pW}$$

Where,

L_w = Sound Power Level



L_p = Sound Pressure Level

A = The effective radiating surface area at the point of the pressure level measurement, m^2

In general, the ostensible magnitude of a sound power level is always considerably higher than the sound pressure level near a source because of the area term. For example, the sound pressure level at 100 m from a wind turbine might be about 53 dBA and the area term at this distance ($10 \log (4\pi 100^2)$) would be 51 dBA with a resulting total power level of 104 dBA re 1 pW (the units of power levels are always denoted as decibels with reference to 1 picoWatt, or 10^{-12} W).

The fundamental advantage of a power level is that the sound pressure level of the source can be calculated at any distance; hence its importance to noise modeling.

3.3 CRITICAL DESIGN LEVELS

From the field survey it was determined that the background sound level varies with wind speed. From Table 3.2.1 in the preceding section it can be seen that the turbine sound level also varies with wind speed. The two values must be compared under the same wind conditions. For example, it would be incorrect and meaningless to compare the maximum turbine sound level, which requires high winds for it to occur, to the background sound level on a calm night.

In terms of potential noise impacts the worst-case combination of background and turbine sound levels would occur at the wind speed where the background level is lowest relative to the turbine sound level – or, in other words, where the differential between the background level and turbine sound power level is greatest. The following chart shows that this worst-case situation occurs when the wind speed is around 7 to 8 m/s. A maximum differential of 73 dB between the conservative L90 background level and the turbine sound power level is associated with these wind conditions. At higher wind speeds the background level continues to rise while the turbine sound level remains level or declines making Project noise progressively less audible under high wind conditions.

Table 3.3.1 *Comparison of Background and Turbine Sound Levels to Determine Critical Design Level (at Maximum Differential)*

Wind Speed, m/s	4	5	6	7	8	9	10
Background Sound Level, L90, dBA	32	33	34	35	36	37	39
Turbine Sound Power Level, dBA re 1 pW	97.1	102.0	106.0	108.2	109.4	109.4	106.7
Differential, dB	65	69	72	73	73	72	68

Consequently, the maximum turbine sound power level of **109.4 dBA re 1 pW** associated with 8 m/s wind conditions will be used as the critical design value in the noise modeling assessment.

Because the frequency content of the turbine sound power level at 8 m/s is not given in the Vestas report for the 3 MW unit, the octave bands have been estimated by adding 6 dB to the spectrum reported for the V90 2 MW unit. The resulting spectrum below will be used in the modeling study.



Table 3.3.2 *Vestas V90-3.0 MW Sound Power Level Frequency Spectrum
Estimated from Maximum V90-2.0 MW data*

Octave Band Center Frequency, Hz	31.5	63	125	250	500	1k	2k	4k	8k	dBA
V90-2.0 MW Sound Power Level at 7 m/s, dB re 1 pW	114.8	111.8	107.8	103.5	100.1	97.7	94.6	91.0	78.4	103.2
Adjustment Factor, dB	6	6	6	6	6	6	6	6	6	
Estimated V90-3.0 MW Lw at 8 m/s, dB re 1 pW – Design Level	120.8	117.8	113.8	109.5	106.1	103.7	100.6	97.0	84.4	109.4

3.4 NOISE MODELING METHODOLOGY

Using the design sound power level spectrum in Table 3.3.2 above, worst-case Project sound levels were calculated using the Cadna/A®, ver. 3.5.115 noise modeling program developed by DataKustik, GmbH (Munich). This software enables the Project and its surroundings, including terrain features, to be realistically modeled in three-dimensions. The modeling software is essentially an automated version of ISO 9613-2 *Acoustics – Attenuation of sound during propagation outdoors* [Ref. 3], which is the primary worldwide standard for such calculations.

The somewhat complex topography of this site has been incorporated into the model using topographical maps of the area.

Each turbine is represented as a point noise source at a height of 80 m above the local ground surface (typical design hub height).

A somewhat conservative ground absorption coefficient of 0.5 has been assumed in the model since all of the intervening ground between the turbines and potentially sensitive receptors is essentially wooded, which is acoustically soft. The ground absorption coefficient (from ISO 9613) ranges from 0 for water or hard concrete surfaces to 1 for absorptive surfaces such as farm fields, woods or sand. Consequently, a ground absorption coefficient on the order of 0.8 or 0.9 could be justified here; however, to be conservative a value of 0.5 has been used.

Although wind direction effects can be modeled with this software, to be conservative the sound level from each turbine is assumed to be the downwind sound level in *all directions simultaneously*. Although physically impossible, an omni-directional wind is assumed. This approach yields a contour plot that essentially shows a sound level at any given point that could only result if the point were exactly downwind of every turbine in the Project at the same time. The sound level between two units, for example, assumes the wind is blowing from each turbine towards the observation point, whereas in reality the downwind contribution would be experienced from one unit while the noise from the other would be diminished – resulting in a lower actual sound level than predicted by the model. In a more realistic scenario with, for example, a prevailing wind out of the west the contour lines would occur closer to the turbines on the west side and would remain largely as shown on the east.



At the risk of overestimating potential Project sound levels, the various conservative assumptions in the modeling analysis have been applied to help ensure that Project noise does not exceed predicted levels under most normal conditions and also to allow some design margin for times when atmospheric conditions may favor noise propagation relative to average conditions, such as at night and during temperature inversions. Sound levels that are lower than those predicted in the modeling plots are expected to occur much of the time. The model represents a theoretical worst-case condition at any given receptor point that would require a convergence of the following conditions:

- **Wind Direction** – from *all* the turbines towards the receptor point
- **Wind Speed** – an 8 m/s wind represents worst-case conditions since the least amount of masking noise is likely to be present relative to the turbine sound level
- **Low Ground Porosity** – normally wooded areas are more absorptive than assumed in the model
- **Observer Outside** – the plotted sound levels occur outside; sound levels inside of any dwelling will be 10 to 20 dBA lower

3.5 MODEL RESULTS

The overall results from the model are shown in **Plot 1**, which illustrates the Project-only sound levels that might occur under the conservative assumptions described above in Section 3.4.

Sound levels have been mapped out to 36 dBA, the critical design value during worst-case 8 m/s wind conditions (see Table 3.3.1), where it is expected that Project noise will be equal in magnitude to the near-minimum natural background level and therefore largely insignificant. Beyond this 36 dBA threshold Project noise is unlikely to be clearly perceptible under most normal atmospheric conditions. Inside of this threshold the turbines would become progressively more audible above the background level.

Plot 1 illustrates that all of the nearest potentially sensitive receptors are outside, and in many cases well outside, of the area where the turbine noise might be clearly audible; consequently, no significant adverse impact is expected from the Project.

It is conceivable that under certain atmospheric conditions, when the temperature gradient and/or wind shear profile are unusually favorable to sound propagation, operational noise from the Project may be perceptible at the nearest cabins on the site property to the east at Millsfield Pond and to the west at Phillips Pond; however, if this were to happen the turbine sound levels would be extremely low and the phenomenon would be temporary in nature. At the nearest off-site residences it is highly unlikely that the turbines would ever be audible under any atmospheric conditions.

The Balsams resort and Dixville Notch State Park are also outside the nominal 36 dBA threshold of perception so Project noise should be inconsequential under most normal conditions at either of these potentially sensitive receptors.

At the Balsams Ski Area the topography is such that Project noise is unlikely to be perceptible largely because the ski area is on a slope facing away from the Project area; however, at the very top of the mountain (only) this topographical shielding effect no longer exists and the turbines will be visible on the next ridge and may be faintly audible. A very low sound level of about 38 dBA is predicted at the summit of the ski area.

In general, it should be noted that the perceptibility of Project noise below about 36 dBA is likely to be intermittent in nature at best because these predictions are only valid for a worst-case 8 m/s wind. Recalling Table 3.3.1, potential impacts will nominally be lower under all other conditions.



In addition, Plot 1 is intended to conservatively represent Project noise emissions, since for the predicted sound levels to actually occur the following conditions would be necessary:

- The wind would need to be blowing from all the nearest turbines directly towards the point of observation
- The wind would need to be blowing at a speed of 8 m/s (as measured at 10 m)
- The ground surface would need to be semi-reflective rather than absorptive
- Observer outside (inside levels should be 10 to 20 dBA lower)
- Environmental noise temporarily at a minimum (L90 level)

These conservative assumptions and worst-case conditions have been consciously adopted for the analysis because the perceptibility of turbine noise does vary with atmospheric conditions and time of day. Consequently, there are likely to be times, when the conditions are right, when the actual impact may approach or exceed the conservatively predicted levels in the plots. Of course, there will also be times, probably the majority of the time, when the perceptibility of Project noise will be less than indicated in the graphics.

3.6 LOW FREQUENCY NOISE

Modern wind turbines of the type proposed for this project do not generate low frequency or infrasonic noise to any significant extent and no impact of any kind is expected from this. Early wind turbines with the blades downwind of the support tower were prone to producing a periodic thumping noise each time a blade passed the tower wake - but this effect no longer exists with the upwind blade arrangement used today.

Concerns about excessive low frequency noise from proposed wind farms are commonly voiced but they have apparently grown out of misinformation or anecdote (probably stemming from early downwind turbine designs) without any basis in current fact. The widespread belief that wind turbines generate excessive or even harmful amounts of low frequency or infrasonic noise is evidently based on a confusion of the amplitude modulation typical of wind turbines (i.e. the periodic swishing sound with a frequency of about 1 Hz) with low frequency sound.

A new study has been recently completed by Sondergaard [Ref. 10] with the specific objective of determining whether large wind turbines produce significant low frequency noise. Extremely careful measurements were made based on the IEC 61400-11 measurement procedure using multiple elaborate microphone windscreens to preclude low frequency self-noise contamination. The results of this testing show that for a typical turbine its sound levels taper down steadily in magnitude towards the low end of the frequency spectrum and that the sound energy below about 40 Hz is actually comparable to or less than the sound energy in the natural rural environment where the measurements were made (as shown in Figure 3.6.2).

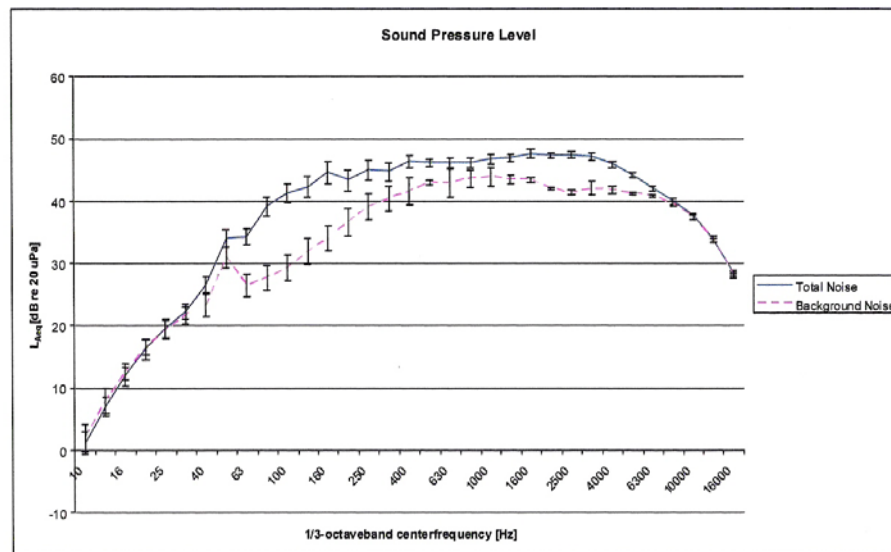


Figure 21 Spectra of total noise and background noise for a 1.5 MW wind turbine. A 50 Hz frequency from a nearby power line influences the measurements.

Figure 3.6.2 Measured Turbine Sound Level down to 10 Hz Relative to Background Sound Level (Sondergaard)

3.7 CONSTRUCTION NOISE

Because of the large buffer distances noise levels from construction activities associated with the Project are expected to be minimal at the nearest potentially sensitive receptors to the site.

Construction of the project is anticipated to consist of several principal activities:

- Access road construction and electrical tie-in line trenching
- Site preparation and foundation installation at each turbine site
- Material and subassembly delivery
- Erection

The individual pieces of equipment likely to be used for each of these phases and their typical noise levels as reported in the *Power Plant Construction Noise Guide* (Empire State Electric Energy Research Corp., [Ref. 6]) are tabulated below. Also shown are the maximum total sound levels that might temporarily occur at the nearest seasonal cabins on the site property (about 9500 ft. from the nearest turbines) and also at the closest permanent residence east of the Project (roughly 15,700 ft. away).

Table 3.7.1 Construction Equipment Sound Levels by Phase

Equipment Description	Typ. Sound Level at 50 ft., dBA [Ref. 6]	Est. Maximum Total Level at 50 ft. per Phase, dBA*	Max. Sound Level at Nearest Seasonal Residences, 9500 ft., dBA	Max. Sound Level at Nearest Off-Site Residences, 15,700 ft., dBA
Road Construction and Electrical Line Trenching				



Equipment Description	Typ. Sound Level at 50 ft., dBA [Ref. 6]	Est. Maximum Total Level at 50 ft. per Phase, dBA*	Max. Sound Level at Nearest Seasonal Residences, 9500 ft., dBA	Max. Sound Level at Nearest Off-Site Residences, 15,700 ft., dBA
Dozer, 250-700 hp	88	92	31	22
Front End Loader, 300-750 hp	88			
Grader, 13-16 ft. blade	85			
Excavator	86			
Foundation Work, Concrete Pouring				
Piling Auger	88	88	27	18
Concrete Pump, 150 cu yd/hr	84			
Material and Subassembly Delivery				
Off Hwy Hauler, 115 ton	90	90	29	20
Flatbed Truck	87			
Erection				
Mobile Crane, 75 ton	85	85	24	15

* Not all vehicles are likely to be in simultaneous operation. Maximum level represents the highest level realistically likely at any given time.

What the values in this table generally indicate is that, depending on the particular activity, sounds from construction equipment are likely to be comparable to the background level - even during calm wind conditions when the L90 level is around 27 dBA - and therefore hardly perceptible, if they are audible at all.

At such low levels any significant annoyance or disturbance at the residences and other receptors around the site area would be highly unlikely.

4.0 CONCLUSIONS

A field survey of existing sound levels in the vicinity of the proposed Granite Reliable Power Project was carried out to determine how much natural masking sound there might be in the vicinity of the site area and how it might affect the perceptibility of noise from the Project.

In general, the near-minimum background levels, characterized by the L90 statistical sound level, were found to be fairly low - even at moderate wind speeds. At the critical wind speed of 8 m/s, for instance, when turbine noise was determined to be greatest relative to the background level, a level of 36 dBA was measured. At higher wind speeds the background level continues to rise while the turbine sound level remains level or declines making Project noise progressively less audible under high wind conditions. At lower wind speeds turbine noise diminishes rapidly and is zero below the cut-in wind speed of around 3 m/s.

Based on the most recent site plan (Nov. 2007), the projected noise emissions from the Project were conservatively modeled and mapped over the site area in accordance with appropriate ISO



standards. The somewhat complex and mountainous topography of the area was accurately recreated in three-dimensions in the model. The sound power level used in the model for the Vestas V90-3.0 MW turbine was developed from field testing in accordance with IEC 61400-11.

The model results, combined with the findings of the background sound level survey, indicate that all of the potentially sensitive receptors surrounding the Project area are beyond the nominal threshold of perceptibility; i.e. a Project-only sound level below, and in most cases substantially below, the natural background sound level is anticipated at each receptor. A significant adverse reaction to turbine noise when its magnitude is equal to or less than the background level is highly unlikely; consequently, no significant adverse impact is expected from the Project.

In addition, it is important to note that the modeling has been carried in a consciously conservative manner and lower sound levels than shown in the plots and discussed above may actually occur much of the time. This approach was taken in recognition of the fact that predictions made using ISO 9613, the worldwide standard for noise propagation calculations, characterize sound levels under average or normal conditions. There will be times when atmospheric conditions, temperature gradients and wind shear gradients cause sound levels at any given location to vary above and below the nominal prediction value. This means that higher sound levels from the project may occur from time to time and that there is a chance that operational noise may be temporarily perceptible at some of the nearest receptors (only).

Although concerns are sometimes raised with respect to low frequency or infrasonic noise emissions from wind turbines, no adverse impact of any kind related to low frequency noise is expected from this Project. The widespread belief that wind turbines generate excessive or even harmful amounts of low frequency noise is evidently based on misinformation or a confusion of the amplitude modulation typical of wind turbines (i.e. the periodic swishing sound with a frequency of about 1 Hz) with low frequency sound. Numerous studies show that the low frequency content in the sound spectrum of a typical wind turbine is no higher than that of many other common sounds.

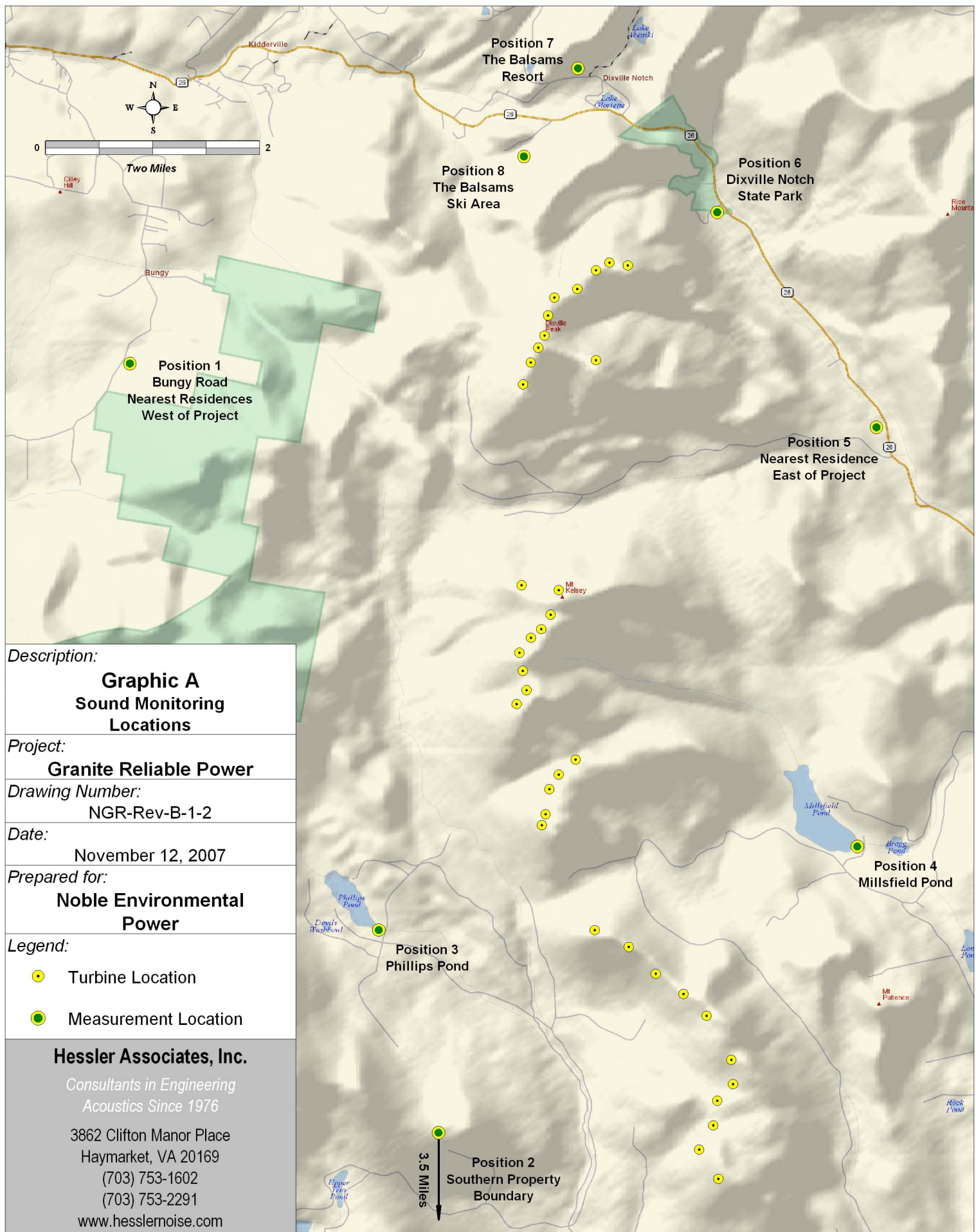
Noise levels during construction of the Project are anticipated to be comparable to the quietest background sound level at the nearest potentially sensitive receptors and therefore inconsequential.

END OF REPORT TEXT



REFERENCES

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Description:

Graphic A
Sound Monitoring
Locations

Project:

Granite Reliable Power

Drawing Number:

NGR-Rev-B-1-2



Date:

November 12, 2007

Prepared for:

Noble Environmental
Power

Legend:

-  Turbine Location
-  Measurement Location

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